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PACERS: Platoon Aid for Collective Employment of Robotic Systems

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U.S. Army Research Institute

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14. ABSTRACT *(Maximum 200 words)*:

This report presents guidance to help train platoons equipped with organic unmanned systems. The Army currently is supplying platoons with both prototype and commercially available unmanned systems to evaluate military utility and to develop tactics, techniques, and procedures; however, the training provided prior to these "experiments" focuses almost entirely on individual operator training. While different unmanned systems require different detailed procedures, there are certain aspects of operation applicable across systems, and training could be given on these system-general aspects of employment. The purpose of this report is to (1) lay out these system-general aspects and (2) suggest a list of activities to focus on to help train system integration. Each activity has associated observations and related after-action review questions applicable to both air and ground assets, and avoiding the particulars of any specific system. Trainers will not have the opportunity to become conversant with the specifics of the myriad of systems they may encounter. Besides being system-general, the training guidance provided is also mission-general. It suggests appropriate observations and questions to facilitate coaching and after action review discussion specifically with respect to system employment. Therefore, these represent an addition to, not a replacement of, mission-specific observations and after-action review topics.

15. SUBJECT TERMS

Platoon, unmanned, robotic, training, after-action-review, RSTA

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Research Report 1876

PACERS: Platoon Aid for Collective Employment of Robotic Systems

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PACERS: PLATOON AID FOR COLLECTIVE EMPLOYMENT OF ROBOTIC SYSTEMS

EXECUTIVE SUMMARY

Research Requirement:

Unmanned or robotic systems (RS) are envisioned to be a key part of the Army's future force. One motivation for the addition of RS is to provide greater reconnaissance, surveillance, and target acquisition (RSTA) information, with less risk to manned elements. Research and development with RS has tended to neglect employment training, however. When putting prototypes in the hands of Soldiers, individuals or operator teams receive operator training, and then units are expected to employ the system in a mission context in order to evaluate military utility or explore tactics, techniques and procedures (TTP). Without some explicit guidance or feedback on techniques and procedures, however, the unit may never properly examine tactical utility (Alberts & Hayes, 2002; Durlach, 2005). This may particularly be the case when operators are designated, rather than dedicated, as is envisioned for operators of the future Class I unmanned aircraft system. There is a need to get units functioning efficiently on techniques and procedures prior to evaluating the tactical utility of a prototype or prior to training on tactics with an operational system.

Procedure:

From readings, discussions, and interviews with people involved in research and development concerning small RS, and from actual observation of training with small RS, it appeared that several activities and goals involved in RS employment techniques and procedures are common across systems. Focusing on a platoon with organic RS assets, guidelines were formulated in terms of how to observe whether the unit engaged in these activities and achieved these goals. In addition, questions to support coaching and after action review discussion were generated. The resulting tool is called PACERS: Platoon Aid for Collective Employment of Robotic Systems. The initial draft of the PACERS guide was assessed by the author during the Micro Aerial Vehicle Advanced Technology Demonstration 2007 Soldier experiment, during which a Stryker Reconnaissance Platoon experimented using a prototype Class I unmanned aircraft system in various mission contexts. The guide was then revised based on observations made during the experiment as well as additional feedback on an earlier draft from subject matter experts.

Findings:

If small robotic systems are going to be employed to gather real-time RSTA information during a mission, as opposed to merely during pre-mission reconnaissance, the employing platoon must become adept at planning and coordinating so that the robotic asset is positioned in the right location at the right time. This will require close coordination between commanders and operators, both in planning and execution. It is crucial that operators understand commander's intent, and just as crucial that the commander understands the restrictions and limitations of the system's capabilities posed by terrain, communications links, battery-life, etc. It is yet to be determined whether platoons will be able to function with designated operators, as opposed to specialized,

dedicated operators. The PACERS tool should assist in making that determination, by facilitating the initial collective training phase of system employment.

Utilization and Dissemination of Findings:

Any platoon-sized or smaller unit tasked with employing small RS for the service of their own missions could benefit from the utilization of PACERS. It is recommended that unit leaders and unit trainers familiarize themselves with the PACERS table. This will provide a focus on the activities and goals the unit should adopt in order to employ the RS effectively. PACERS suggests what behaviors to look for, and what questions to ask, to facilitate mastery of system employment. The author welcomes feedback from any units that utilize this product.

An earlier version of this report was circulated to potentially interested parties at PM Future Combat System, PM Unmanned Aviation Systems, Training and Doctrine Command, Program Executive Office Simulation, Training, and Instrumentation Command, Army Research Laboratory, Office of the Secretary of Defense, Robotics Systems Joint Program Office, Infantry Combat Development Center, Defense Analysis Research Projects Agency, Air Assault Expeditionary Force, and the Soldier Battle Laboratory. Feedback was mixed, with comments from different responders diametrically opposed. Some respondents thought the material in the report was right on target, timely, and needed, whereas others thought it was not useful (too generic) or already known. Many of the comments have been incorporated into the final draft.

PACERS: PLATOON AID FOR COLLECTIVE EMPLOYMENT OF ROBOTIC SYSTEMS

CONTENTS

LIST OF TABLES

Page

LIST OF TABLES

LIST OF FIGURES

PLATOON AID FOR COLLECTIVE EMPLOYMENT OF ROBOTIC SYSTEMS (PACERS)

INTRODUCTION

This report explains, in a generic way, what is involved in the employment of an organic unmanned system for the purposes of reconnaissance, surveillance, or target acquisition (RSTA). Although different current-day systems differ in their details, they all share several common employment aspects, and making these common aspects explicit may aid leaders and trainers in understanding system requirements and employment considerations. There is a need for system-generic guidance, because the Army is currently in an exploratory phase testing different prototype or commercially available systems, and trainers at places like the Joint Readiness Training Center or the National Training Centers will need to provide guidance without detailed knowledge of the specific systems they may encounter. It is anticipated that trainers will have the same problems coaching robotic employment as they currently have with coaching the use of digital battle command systems. With digital battle command systems, each rotation comes to training with a unique collection of digital command and control systems. Moreover, individual systems are continually evolving and up-to-date technical manuals are not necessarily available. For example, the "Digital TOC Integration Guide" (Leibrecht, Lockaby, Perrault, Strauss, & Meliza, 2006) is already considered outdated. The rapidly changing technology of digital command and control and of unmanned systems makes it difficult for trainers to provide guidance on how to apply these technologies unless they can address their employment in a generic way.

The report groups the common aspects of unmanned system employment into seven categories or activities. These activities and the associated goals of these activities are listed in Table 1. For each of these, there are suggested observations that trainers can make and questions that trainers can ask, to help coach system employment. These will be explained further in the body of this report.

The activities, goals, observations and questions suggested as aids to training will be referred to collectively as Platoon Aid for Collective Employment of Robotic Systems (PACERS). PACERS focuses on the procedures and techniques involved in the employment of small unmanned ground vehicle systems (SUGV) or small unmanned aviation systems (SUAS). In order to emphasize the generic nature of PACERS, this report will simply call these robotic systems (RS). PACERS does not address operator training. It assumes operators have been trained in the detailed elements required for control of the specific RS system in use; although it does not assume that the training has been perfect, nor executable in a tactical context without some supervision.

The term "small" here refers to RS where all system components (i.e., platform or vehicle, control and communication equipment, and payload) are transportable by dismounted troops. Such systems have relatively low logistics requirements, which allow them to be used without an established base of operations (such as required by large fixed wing aircraft). Ideally, they provide the commander with real time information about the immediate surroundings; what's over the next hill, in the next alleyway, or on the roof of a building. It is these small systems that are most likely to be deployed organically at the platoon level.

Table 1. Activities and Goals Addressed by PACERS

Activity	**Goals**
Decide whether/how to employ the RS	▪ Potential benefits vs. risks of employing the RS are considered in light of overall mission objectives, METT-TC, and weather.
Select RS **team*** and plan RS missions within the overall mission context ***RS team**—any personnel involved in - Operation of the RS - Interpretation and/or communication of information gained from the RS - Security for above	▪ Provide adequate number of personnel to conduct RS operations and provide security ▪ Ensure RS team members understand their mission ▪ Ensure RS employment is integrated into the overall mission
Define roles of unit personnel in tracking the RS mission, interpretation of RS sensor imagery, and reporting on CCIRs.	▪ Intel acquired by the RS gets to the people who need it in a timely manner. ▪ RS mission can be dynamically re-planned based on new intelligence
Pre-deployment checks	▪ Necessary RS-related equipment and supplies are present and in fully working order ▪ Communication frequencies for operator use have been cleared with higher and specified to operator ▪ Radio nets for voice communications specified and checked ▪ Coordination with higher on A2C2 (for air platforms)
Develop or refine unit SOPs and TTPs	▪ Improve efficiency and effectiveness of RS employment
Record keeping	▪ Safety incidents recorded and reported ▪ Use and Maintenance logs kept up to date ▪ Operator training currency and logbooks kept up to date
Preparation for launch and recovery at a remote site	▪ RS team safety ▪ Timely RS launch

A2C2 = Army Aviation Command and Control
CCIR = Commander's Critical Information Requirements
METT-TC = Mission, Enemy, Time, Troops, Terrain, and Civilians
SOP = Standard Operating Procedure
TTP = Tactics, Techniques, and Procedures

Integration of unmanned systems may be particularly challenging at the platoon level. This is because the extra workload and synchronization required for system employment will fall on platoon leaders, the Army's least seasoned commanders. In addition, because unmanned systems at the platoon level may be operated by designated, as opposed to specialized personnel

(Office of the Secretary of Defense, 2002), there will be extra challenges in terms of manpower allocation and delegation of responsibilities.

PACERS is based on the state of RS technology as it exists in 2007. It should be useful for training platoons assigned to test prototype RS or platoons actually equipped with new small RS within the next several years. PACERS is just a starting point for collective training. The particular behaviors and questions associated with each set of activities and goals may be modified by trainers according to individual systems, changes in technology, or changes in unit organization; however the underlying activities and goals should remain relevant despite such changes.

PACERS was compiled because there is a lack of training guidance with respect to the employment of small RS at the platoon level. This is not surprising. It is currently rare for an RS to be given to a platoon as an organic asset to be used in the service of their own missions. However, the Army has been testing experimental systems under such conditions, and intends to equip platoons with such systems in the future. Infantry platoons under the Future Combat System (FCS) are expected to have SUAS and SUGVS as organic assets. The Army needs to test prototype systems in mission contexts; but there is currently no guidance on conducting collective training with RS.

This work was conducted under the Leader Adaptability Army Technology Objective (ATO), performed by the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI). This ATO has the general goal of enhancing battle command training by better understanding the impact of networked battle command on leadership and battle command skills and by identifying learning methods and techniques to develop the required skills. The specific goal of the current work was to consider the training that will be required as small RS are introduced into the force. Currently, such training is concentrated on the operators of RS, and there is a lack of consideration for the collective aspect of employment. PACERS was developed to fill this need.

In work performed under ARI's prior Methods and Measures of Commander Centric Training ATO, the impacts of networked command, control, and communication (C3) systems on the training process were considered. Issues concerning the employment of networked C3 systems add substantially to the topics that may be addressed during training. To help leaders and trainers address unit application of the Force XXI Battle Command, Brigade and Below (FBCB2) system and C3 systems in the tactical operations center (TOC), ARI developed the FBCB2 Exploitation Tool (Leibrecht, Lockaby, and Meliza, 2003) and the Digital TOC Integration Guide (Leibrecht, Lockaby, Perrault, and Meliza, 2006), respectively. PACERS is intended to be a guide of the same vein. That is, it is aimed at assisting trainers with the additional topics that will need to be addressed when RS are employed in a collective mission. Unlike these previous products, however, PACERS is intended to be applicable across a range of systems.

BACKGROUND

RS are envisioned to be a key part of the Army's future force. One motivation for the addition of RS is to provide greater RSTA information, with less risk to manned elements. The FCS is the material solution to equip the future force, including RS. The backbone of FCS will be an advanced communications network, intended to enhance situational awareness, situational understanding, and synchronization of operations. The network will transmit the RSTA information collected by RS to decision makers, so that it can contribute to their situational awareness and understanding.

In the original FCS vision, each echelon of the FCS Brigade Combat Team (BCT) from platoon up through brigade was expected to have organic unmanned aviation systems, referred to as Class I through IV, respectively. The Class I (platoon level) was to provide the dismounted Soldier with RSTA and communications relay services. The Class I should be backpackable and capable of operating in urban terrain. It should have vertical takeoff and landing capability, as well as a modular payload capability. For example, its payload might be changed from an electro-optical (EO) color camera to an infrared (IR) camera .

Various unmanned ground vehicles would also be employed at the platoon level (dependent on mission). These include the SUGV, the Armed Robotic Vehicle (ARV), and the Multifunctional Utility/Logistics and Equipment (MULE) vehicle. The SUGV would be a small, lightweight, man-portable vehicle capable of operating in urban terrain, tunnels, and caves. Like the Class I, it will have modular payloads, enabling it to perform a variety of high-risk RSTA missions including chemical detection. In addition, the SUGV might be used for more than just RSTA; payloads might include articulated arms for remote manipulation, or weaponry. Relative to the SUGV, the ARV and MULE would be large vehicles that can support mounted or dismounted forces, with modular payloads to support various missions.

The current FCS program timeline incorporates four "spirals." In each spiral, new equipment will be tested by the FCS Evaluation Brigade Combat Team, and then subsequently introduced into the current force. The purpose of these spirals is to get new technology into the hands of Soldiers as soon as they become available. These spirals are slated to occur in 2008, 2010, 2012, and 2014.

The FCS represents the official material development route for the future force; however, other activities have already put small RS into the hands of Soldiers. This has been accomplished through rapid equipping initiatives. One such initiative, for example, provided Soldiers with Packbots modified to assist in explosive ordinance disposal missions. Advanced Concept Technology Demonstration (ACTD) projects have also developed small RS that have subsequently been adopted by the Army. For example, the fixed-wing Raven SUAS was initially developed by the Pathfinder ACTD. A ducted-fan prototype Class I has been developed by the Micro Air Vehicle (MAV) ACTD, and is currently under evaluation by the 25th Infantry Division. In fact, the Army has been experimenting with small RS for several years already, to evaluate their performance capabilities and how their employment will fit into future missions. One example is the Air Assault Expeditionary Force (AAEF), a multiyear project initiated in 2003, which conducts discovery experiments with emerging technologies in a live field

environment (U.S. Army Training and Doctrine Command Office of the Chief of Public Affairs, 2006). One of their foci is to address employment of sensors and sensor management at the small unit level.

Heretofore, collective training with respect to small RS has received scant training time. Often, if collective training is given, it takes the form of briefings, rather than live or simulated training exercises; and the first opportunity for collective employment may not occur until the equipped unit reaches the National Training Center. With respect to experimentation, it is the same story. Typically individuals or operator teams receive hands-on operator training. Then their units are expected to employ the system in a mission context in order to evaluate military utility. It is not typical for the unit to be given any prior training on TTP before the evaluation phase, except perhaps via briefing. In the AAEF Spiral C report (Meshesha, et al.,2007), the authors explicitly acknowledge that such training could make their future experiments far more profitable in terms of exploring military utility and useful tactics. As they say, "TTP and lessons learned from previous spiral experiments must be included in the technology train-up in follow-on spirals, to avoid 'relearning the wheel' in each spiral (page 3-19)".

Hands-on unit level training that is not part of formal experimentation could greatly enhance the benefits of exploratory experiments, as well as subsequent operational efficiency. Unit training concerns the integration of system employment into the organization of responsibilities of the unit as a whole. Individual operator training is not sufficient for system employment. Unit commanders and squad leaders require training on system capabilities and requirements, as well as the practicalities of integrating system use into their operations. There is enough commonality in goals and activities across systems to allow for initial collective practice involving planning, synchronization, and communications. Such training could maximize the amount of time a unit spends establishing the more tactical aspects of TTP and minimize the time spent on working out responsibilities and coordination issues. The immediate aim of PACERS is to help facilitate this initial training stage of RS employment in a unit context, so that the team dynamics can be more quickly established and the ultimate goal of determining tactical utility can be addressed. The longer term aim of PACERS is to assist in collective training once operational units actually are assigned small RS.

There are several challenges involved in the integration of RS into the force, whether the RS be large or small. In order to be a force multiplier, these systems must be relatively easy to maintain, control, and employ. The benefits of employing the RS must more than offset the burden in terms of personnel requirements, workload, and operations tempo. For example, a SUGV that requires two operators plus a security detachment, and that cannot travel as fast as a dismounted Soldier could be more of a burden than an asset. Much of the research in RS has been devoted to increasing system intelligence and autonomy in order to reduce the operational burden. One focus of this development has been on making system behaviors more autonomous in order to relieve the operator from having to control everything the system does. A first step is to replace direct control of electro-mechanical changes with higher level instructions. For example, to raise altitude, a flight operator could select a raise-altitude-function, without having to be aware of the necessary mechanics for doing this (e.g., changes in pitch, yaw, engine revolutions, etc.). This step has been achieved for many prototype systems. Moreover, several RS allow the operator to program a route by designating a series of waypoints along with

velocity, and other aspects of platform behavior. During program execution, control software converts these directions into the electro-mechanical behaviors required, allowing the operator to concentrate on sensor data, rather than flight/maneuver control.

Strides are being made in the area of autonomous behavior, but these accomplishments will always be limited by developments in the area of autonomous sensing. The challenge is to provide RS with some degree of situation awareness and understanding. This will require breakthroughs in networking, image processing, and data fusion. With these breakthroughs, there is the potential to release operators from having to monitor the sensor data constantly for obstacles or targets. In the absence of significant progress in these areas humans will be required to monitor, interpret, and disseminate information obtained from remote sensors.

PARTICULAR CHALLENGES AT PLATOON LEVEL

The actionable use of real-time sensor data by a small unit, such as a platoon, may be limited to pre-mission reconnaissance, unless the workload demands of system employment can be minimized. Consider a platoon with a mission to enter an urban neighborhood and secure a building. During the actual assault will the platoon leader (PL) have personnel to spare for RS operation? If he chooses to employ the RS, how will he coordinate its actions with those of his other assets? If the PL is remote from the operator, how will they maintain common situation awareness? Will the PL have time to keep abreast of the information provided by the RS and use it to make mid-mission adjustments?

The current vision for the future force is that RS operators at the platoon level will be “designated, not dedicated.” The platoon will not have a special attachment of personnel to operate the RS. The operator team must be drawn from the pool of personnel within the platoon (and platoons are not envisioned to become larger). In addition, it might be necessary to provide the operator team with a security detachment, if they are remote from the rest of the platoon. The attentional demands of system operation (at least currently) do not allow operators to also maintain their own safety. Several experiments with RS at the platoon level indicate this is an issue for PL. For example, the PL participating in both the 2005 and 2006 MAV ACTD Soldier experiments felt they needed more people to properly utilize the MAV in coordination with an ongoing mission. They were both concerned that to use the MAV, they had to “pull people out of the fight” and so reduce their fire power. The same reservations were expressed after AAEF spiral C (Meshesha, et al., 2007).

Another issue is the current lack of digital networking. Few RS are networked to any other Army digital systems. Consequently, the operator team may have difficulty maintaining awareness of the rest of the unit’s situation (unless they are in sensor view or the team has other systems providing blue-force tracking). Without this awareness the operator may be unable to tailor real-time information gathering to unit needs. This was a particular concern of the PL in the 2006 MAV ACTD Soldier experiment. He mentioned that his operators tend to lose situation awareness, so even when they were operating on the move from a Stryker with the rest of their squad, personnel from that squad were needed to supervise them, again removing people from the fight.

The PL may or may not have access to the sensor data through a remote video terminal (RVT). If available, the RVT may or may not provide information about sensor location. Without this, the PL may have difficulty using the sensor data without additional voice communication with the operator team. Even if the PL has all this information within arm's reach, he may not have the resources to monitor it. Unlike at higher echelons, the PL does not have a staff to monitor, filter, and interpret intelligence information. Voice communications with a remote operator team will likely be essential and this will increase the number of radio nets required for the PL to monitor. Meshesha, et al. (2007) suggest that a specialized robotics non-commissioned officer (NCO) be assigned to these duties.

Another issue is that PL tend to be relatively unseasoned leaders and tacticians. It is not clear that the "see first-understand first" potential of RS will be fulfilled at the platoon level unless specific collective training objectives are outlined for its employment. The most common platoon weaknesses observed at the Joint Readiness Training Center involve errors that could undermine effective use of RS. These include poor troop-leading procedures, failure to conduct mission rehearsal, failure to conduct pre-combat checks, and failure to delegate tasks and responsibilities clearly (Odom, Gates, Hardwick, and Ehrlich, 2005).

According to Switzer (2005), the most common mistake among PL is failure to involve others in planning. Since optimum use of RS will require integrating the RS operator into the planning process, this is a weakness that needs to be overcome. Training for RS employment must include leader training on mission analysis, intelligence preparation of the battlefield, and coordinating timelines and priorities. The capabilities of the RS must be taken into account in terms of weather, terrain, communications range and battery life. Emplacement and recovery sites must be selected, and a security team assigned to protect the RS operations crew. Potential benefits vs. risks of employing the RS must be considered, as well as contingency plans should technical difficulties prevent its use.

Switzer (2005) also suggests that platoons are particularly weak at maintaining shared situation awareness, with respect to the enemy and to adjacent friendly units. This is because the information fails to be communicated, with failures occurring both top-down and bottom-up. Clearly, the extent to which a RS will enhance situation awareness depends on transmission of the information provided within the unit. Since poor communications among platoon members has already been highlighted as a weakness, it is not clear that the mere provision of the RS will provide much of a benefit without dedicated training on team communication and coordination. This also applies across units. If adjacent units are also equipped with RS, coordination between them will be crucial to avoid stepping on one another's radio link frequencies. Units will need to establish procedures on how to communicate and what to communicate, and this will remain an issue at least until RS become a lot smarter and/or integrated with other digital systems.

In summary, to attain the potential benefits of RS, platoons should have mission training objectives involving the employment of RS and train on these. Operator training is not sufficient for proper employment, and briefings are not sufficient to achieve proper coordination and communications. Unless this kind of training is included much time will be expended clarifying misunderstandings in organization, responsibilities, and communications. The purpose of PACERS is to provide experimenters and trainers with some guidelines on how to conduct this

phase, with a guide to diagnose unit employment capabilities and provide self-evaluation and improvement through after action review (AAR) questions.

PACERS was developed on the basis of readings, discussions, and interviews with people involved in research and development concerning small RS. This included companies developing systems, managers and participants of exploratory experiments with systems and reports on those experiments, combat developers, training developers, and initial impressions reports on fielded systems. More information was collected on SUAS than SUGV, because of the networks and contacts the author was able to establish. The initial draft of PACERS was then piloted by the author at the MAV ACTD 2006 Soldier experiment. This piloting did not involve actual application of PACERS as a training intervention; rather, it involved only assessment of whether the items included in the draft tool were relevant, as well as the identification of new elements. This assessment was conducted through observations of commander-operator interaction, AAR, and individual interviews with operators and their platoon leader.

PACERS

The matrix format of PACERS is illustrated in Table 2, which shows one of the seven activities (Decide whether/how to employ the RS), along with associated observations and potential questions. The "Observe" column suggests behaviors to observe which are indicative of the unit accomplishing integration of the RS into their organization. The "Ask/AAR Questions" column suggests questions to ask either during or after a mission, in order to stimulate the unit to think about what they are doing and how to improve organization. Who should be asked is also indicated. The time to use PACERS is subsequent to operator training, when a RS is first introduced to a unit for employment in the context of a training mission.

PACERS does not address operator performance in terms of mastery of purely operator tasks; however, there will likely be some need to check that operator training transfers to the more complex mission context setting. These checks could easily be integrated with the use of PACERS. PACERS does not address performance of any specific military mission, per se (such as route reconnaissance); rather it is to be used in addition to the proficiency observations that would be made for those missions. PACERS does not directly assess tactics, as in most near term opportunities for application, these will not have been developed yet. PACERS could be said to address the "procedures" part of TTP, without getting into the details of specific systems. The full PACERS tool is given in Appendix A.

Besides being used by trainers, PACERS can also be used by platoon members prior to training, in order to identify or review many of the considerations and procedures that are important in the application of RS. It is hoped that use of PACERS in this way will motivate and guide what platoons do to prepare for collective training exercises where RSs are to be employed. Trainers and unit leaders have the option of using the suggested observations and questions for coaching and mentoring activities, in addition to stimulating discussion during AAR.

Table 2. Format of PACERS

Activity & Goals	Observe	Ask/AAR Questions
Activity: Decide whether/how to employ the RS **Goals:** Potential benefits vs. risks of employing the RS are considered in light of overall mission objectives, METT-TC, and weather. **SEE APPENDIX B FOR ADDITIONAL DETAILS**	▪ Was airspace clearance checked (air systems)? ▪ Was there any coordination with adjacent units wrt RS employment? Specifically on communications frequencies? ▪ If indirect fires are available, was there any consideration of how this might impact RS employment?	**<u>Ask Platoon Leader</u>** ▪ What factors did you consider in deciding to employ (or not employ) the RS? ▪ What did you view as the potential advantages of using the RS? ▪ What did you view as the potential disadvantages of using the RS? ▪ Is there a process for coordinating with adjacent units?

METT-TC = Mission, Enemy, Time, Troops, Terrain, and Civilians

The Seven Activities and Illustrative Examples

This section explains the seven activities outlined in PACERS, and provides illustrative examples from the MAV ACTD 2006 Soldier Experiment. Because the purpose of PACERS is to help improve unit performance, examples will focus on errors and deficiencies. This should not be read as evaluation of the ACTD nor the unit. The unit participating in the MAV ACTD 2006 Soldier experiment did not have access to the initial draft of PACERS to help prepare for the experiment; the lessons learned by the unit were incorporated into a revised PACERS document to provide future users of RS with a head start. In order for the reader to better understand the examples below, a more thorough explanation of the MAV ACTD experiment will be provided first.

Participants in the MAV ACTD 2006 Soldier experiment were a relatively newly constituted Stryker Reconnaissance Platoon, of the 25th Infantry Division at Schofield Barracks on Oahu. The experiment was managed on behalf of the ACTD by the Soldier Battle Lab. The experimental system was the g-MAV developed by Honeywell, Inc., a prototype Class I SUAS. The g-MAV is a gasoline fueled vehicle with vertical take-off and landing capability. Its range and endurance depends upon the weather and terrain, but in general it can range out to 10 km, fly up to 1000 feet or more, and has a flight endurance of up to 40 minutes. The vehicle itself is quite loud, and so is not at all stealthy at low altitudes. It can carry two fixed cameras, either EO or IR, transmitting sensor data in near real time. One camera points forward, and the other points downward. The sensor imagery must be interpreted by a human; the system has no object recognition or sense-and-avoid capabilities. It can be flown manually or semi-autonomously, hover, and rotate in place. Line-of-sight (LOS) with the ground control station (GCS) is required for manual flight and streaming video; however, the system is capable of flying autonomously and storing imagery if a preprogrammed flight plan takes it out of direct LOS. It can also be programmed to respond in various ways to loss of communications link with the operator.

Figure 1 illustrates the components essential to operate the g-MAV (and most RS). Two-way communication is required between the operator and the air vehicle ("uplink" and "downlink" in the figure). These communications are handled by the GCS, consisting of an operator control unit (OCU) and ground data terminal (GDT). To distinguish these communications channels from other forms of communications, these channels will be referred to as for up-down links (UDL).

The OCU acts as the human-system interface. It translates human inputs to machine level commands and displays information sent back from the vehicle. The GDT acts as the vehicle-system interface, sending the lower level commands to the vehicle and receiving data from it via the UDL. The Global Positioning System (GPS) supplies both the air vehicle and the GCS with position information via satellites; although the system does have some backup navigation control if GPS information is lost. The GPS information allows the vehicle to follow a pre-programmed route, and allows the operator to keep track of its location, as well as his own location on a situation awareness map. The GCS is not integrated with any other blue-force tracking systems, however. The system can be controlled by a single operator, although launch preparation is more efficient with two people. This way, one person can attend to the actual air vehicle and the other the OCU during the required pre-launch checks. The person at the air vehicle can conduct physical vehicle checks and engine start, while the other person can monitor the data sent back from the vehicle to the OCU.

An official "system" consists of two air vehicles, one GCS and two pairs of payload pods (one EO and one IR); however, during the course of the MAV ACTD experiment, the unit was allowed to use any combination of equipment available. For example, they were not limited to one GCS, which allowed the PL to use a second GCS as a RVT, or to have two operators controlling different air vehicles simultaneously using different GCS and UDL.

The PL and NCO received operator training (one week) from Honeywell engineers at Honeywell facilities approximately one month prior to the experiment. Subsequently, remaining members in the platoon received operator training (one week) from Honeywell engineers at Schofield Barracks, during the week prior to the experiment; however, not all of them could attend the entire training session. Four Soldiers (three privates and a corporal) were fully trained to act as g-MAV operators for the experiment. On average, 15 platoon members participated in each experimental mission, and they were equipped with three or four Stryker vehicles, depending on maintenance status. Training was assisted by three (previously trained) NCO from Operational Test Command, who subsequently assisted in ACTD data collection during the experiment.

The platoon conducted four main missions on Schofield Barracks ranges over the course of a month: Urban Reconnaissance (Day), Urban Reconnaissance (Night) Route Reconnaissance (Day) and Area Reconnaissance (Day). Each mission was performed first without the g-MAV (baseline), and then subsequently at least two times with the g-MAV. Missions lasted between one and four hours, from PL reading his Operations Order (OP-Order) to end of mission

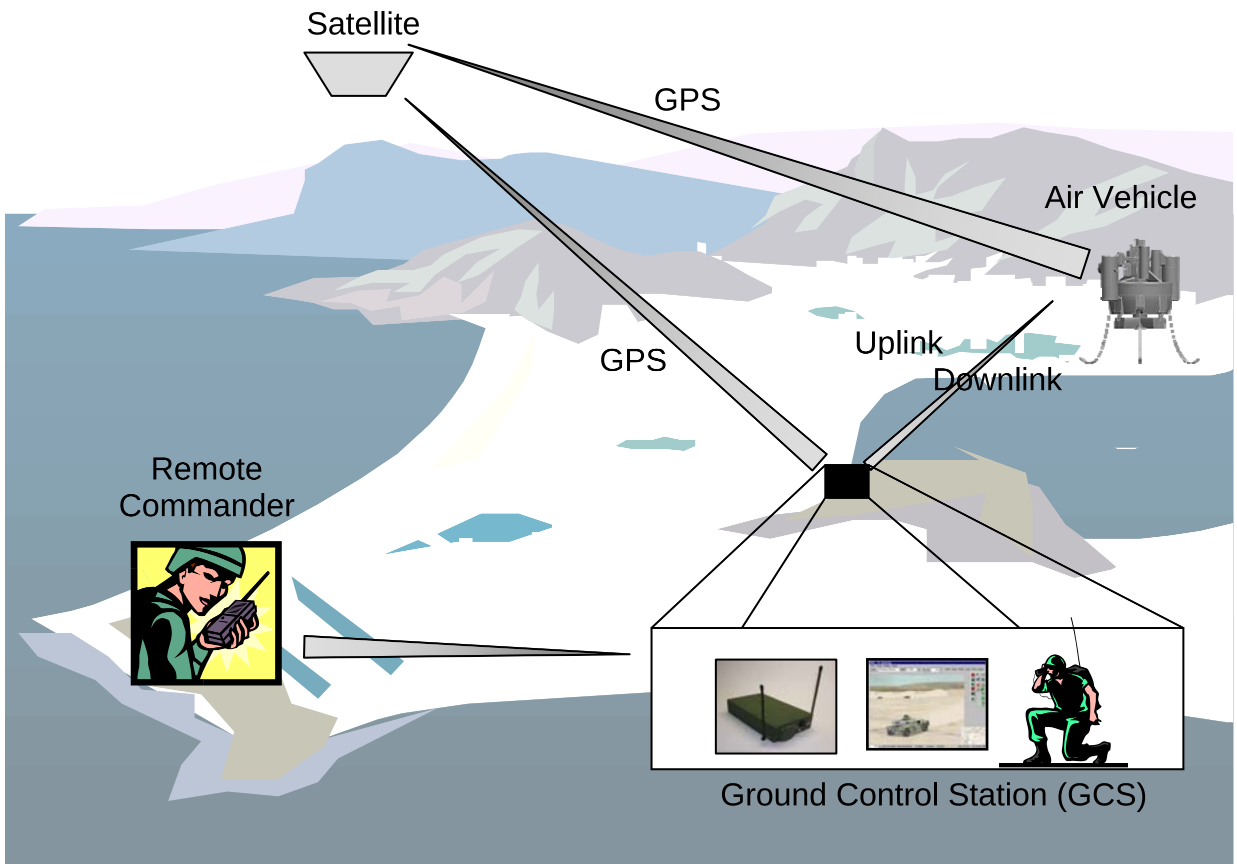

Figure 1. An illustration of the essential equipment for g-MAV operation. The human operator interacts with the ground control station (GCS), which in turn communicates with the air vehicle using the uplink radio frequency. The vehicle can send data down to the GCS via the downlink frequency. Satellites provide information to the global positioning systems (GPS) receivers allowing the GCS to display the location of both the GCS and the air vehicle on a situation awareness display. The primary means of communication between the operator and a remote commander would be by voice radio.

(Endex). Endex was called at either a logical mission conclusion or transition point, or because of technical issues. Missions ending for purely technical reasons were repeated on another day. Most missions were followed up with an AAR, with AAR leadership varying among Battle Lab Staff, PL, or platoon sergeant (PSgt). The Urban Reconnaissance missions involved entering a small village and securing two adjacent buildings. The Route Reconnaissance missions involved traversing and clearing a winding, uphill route, with abrupt elevation changes and dense foliage in adjacent terrain. The Area Reconnaissance missions involved reconnaissance and clearing of a relatively flat area, except for berms and foliage, which obstructed ground-level line of sight. For the Urban Reconnaissance missions the PL chose to employ the MAV from a stationary rear position. For the Route and Area Reconnaissance missions, he used this same strategy for some missions; but also tried controlling the MAV on the move, with the operator mounted on one of the Strykers. For each mission, a varying number of people (6 – 12) were available to play the role of local civilians or hostiles, some unknown number of whom could be hostile and armed,

and who may have emplaced explosive devices in the area. Rules of engagement instructed platoon members not to fire unless an unknown displayed clear hostile intent. Hypothetical indirect fires could be called for during the Area Reconnaissance missions.

Decide Whether/How to Employ the RS

Table 2 (above) lists the observations and questions associated with the activity, "Decide whether/how to employ the RS." The associated goal is to ensure that potential constraints, benefits and risks of employing the RS are considered in light of overall mission objectives, and prevailing conditions (Mission, Enemy, Time, Troops, Terrain, and Civilians, or (METT-TC)). Consideration must be given as to whether employment of the RS will contribute positively to attaining mission objectives. This includes consideration of what potential enemy response to it might be (e.g., if it makes a lot of noise or gives clues to mission objectives). Most RS will have constraints on their employment according to weather, terrain, personnel requirements, available UDL frequencies, and air space privileges (for aerial vehicles). It is important that these factors be taken into account. Dedicated UDL are essential to ensure no interference in operator control. If an adjacent unit were to use the same UDL, there is a potential for loss of control.

All RS will also have operating characteristics that could affect appropriateness of employment. For example, the spatial communication range of the system, its stealth (or lack thereof), and its battery/fuel supply must be factors contributing to determining whether and how to employ the RS in the context of a particular mission. During training, it is important to establish that consideration of these factors becomes a routine step before employing the system. Appendix B contains a more detailed list of considerations, organized by METT-TC.

In the MAV ACTD 2006 Soldier experiment, it was pretty much assumed that if the g-MAV was available (non-baseline mission), and the weather conditions permitted, the unit should use it (as the purpose of the experiment was to give them as much opportunity to try it out as possible). Therefore, in the context of the experiment, the issues listed in this section came more into play in planning how the g-MAV would be used rather than whether it would be used. Nevertheless there were coordination issues that affected whether missions could be conducted. Coordination with range control was required to ensure air space clearance and noninterference with/from adjacent areas. Radio frequencies available for UDL had to be coordinated prior to the experiment.

With respect to how missions would be conducted, one of the prime considerations by the PL in the MAV ACTD 2006 experiment was workload and manpower. He preferred to use the MAV primarily for leader's reconnaissance, prior to maneuver on his main mission. His Strykers were equipped with the Long-Range Advance Scout Surveillance System (LRAS3), providing pretty good sensor coverage even without the MAV. Employing the MAV during maneuver involved removing personnel from the actual operation, and also complicated use of the radio nets (as a net was needed between PL and remote RS team). It also added another synchronization problem to his workload; not only did he have to synchronize squads, he also had to synchronize MAV maneuver with squad maneuver. This was particularly complicated if the operator was not stationary and remote, but instead mounted on one of the Strykers. In this case, issues of terrain (blocking LOS) and landing (recovery) sites for the MAV became

additional factors for consideration. It is important that the PL think through and synchronize all activities if the RS is going to be used during the maneuvering part of a mission, as opposed to only for pre-mission reconnaissance. Indeed, it has been suggested by some subject matter experts that, at least given the current state of the art, RS should be used by small units only for pre-mission reconnaissance, unless the team operating the RS is a specialized dedicated attachment to the unit.

Select RS Team and Plan RS Missions Within the Overall Mission Context

Table 3 lists the observations and questions associated with the activity, “Select RS team and plan RS missions within the overall mission context.” RS team refers to any personnel involved in the RS operation, interpretation and/or communication of information gained from the RS, and security for these personnel. The associated goals involve delegating tasks, assigning responsibilities, integrating the use of the RS into the larger mission plan, and making sure the plans are understood.

One issue that arises when the RS team is designated, not dedicated, is that a different set of people may constitute the RS team from one mission to another. As a consequence, people may not have established roles nor feel responsible for particular duties involved in RS operation, unless explicitly assigned the task. The PL or PSgt should not assume that the RS team will systematically work out these responsibilities on their own. For example, during the MAV ACTD experiment, the RS team had several steps to conduct before the aerial vehicle could be launched. This included vehicle set up, fueling, engine tuning, setting the communications channels, and various pre-flight vehicle checks. One step that could have been conducted ahead of the final launch sequence, but typically was not, was pre-checking the functioning of the UDL between GCS and g-MAV. Despite the fact that the RS team usually had ample time to do so, they often neglected to check this until the planned launch time. Technical problems were often encountered at this stage (either due to user errors or omissions in previous steps or because of genuine hardware/software glitches). Consequently g-MAV launch was delayed until the nature of the problem could be established and corrected. Had the team checked the UDL prior to the scheduled launch time, the delays could have been averted. No one was ever explicitly assigned responsibility for this task, and therefore a pre-check was conducted only when someone happened to show initiative and do it. Only one person ever did this; this was an NCO, not one of the operators. The problem was never addressed during an AAR (why hadn’t the UDL been checked prior to launch?), and continued to be a source of delayed MAV flights throughout the experiment. Unless problems like this are explicitly addressed during AAR they will continue to plague the operation.

It is important that all critical details of the RS mission be specified for the RS team. Especially when the RS team is ad hoc, there should be no assumptions made about what the team already understands or knows about their responsibilities and mission. All the information regarding employment of the RS should be briefed to the RS team, and ideally specified in a written form. Units may benefit by adopting a standard format for this to ensure that no details are omitted. A potential list for inclusion is provided in Appendix C.

Table 3. Planning RS missions

Activity & Goals	Observe	Ask/AAR Questions
Activity: Select RS team* and plan RS missions within the overall mission context **Goals:** ▪ Provide adequate number of personnel to conduct RS operations and provide security ▪ Ensure RS team members understand their mission and individual responsibilities ▪ Ensure RS team has adequate time to move to emplacement site and prepare RS for maneuver ▪ Ensure RS employment is integrated into the overall mission *** RS team**—any personnel involved in - Operation of the RS - Interpretation and/or communication of information gained from the RS - Security for above	▪ Did PL or PSgt ask questions to ensure RS team understood its mission? ▪ Was a rehearsal conducted? ▪ Did the rehearsal cover the entire RS mission? ▪ Were CCIRs/PIRs explicitly discussed? ▪ Did the PL prepare a written RS-OPORDER? ▪ Was all the information required for the RS team operations briefed? (SEE APPENDIX C) ▪ If the RS team would be remote from the rest of the unit was a trigger for reuniting specified? ▪ When entering autonomous missions in the RS OCU, does the user check this mission with respect to terrain/other factors ▪ Was there a discussion on how to program response to loss of UDL links?	**<u>Ask RS Team</u>** ▪ What was your mission? ▪ How did your mission relate to the overall mission? ▪ Were you briefed on all the information you needed to conduct your mission? ▪ Were problems encountered in preparing to launch that might have been addressed with additional personnel? ▪ Did you run into any situations that you were not sure how to respond to? ▪ Was time a problem in preparing for the launch? ▪ Were each individual's responsibilities clearly defined?

PL or PSgt should ask questions of the RS team to make sure they understand their role in the mission in terms of RS operations and the means of communicating RS status and intelligence gathered. Ideally, a mission rehearsal would be conducted, including synchronization of RS operations with the rest of the unit.

During the MAV ACTD 2006 Soldier experiment, the PL was generally thorough in briefing the RS team; however, he did not provide the RS team with a standardized briefing and there were instances when critical pieces of information were omitted. These included how to program the "loss of link" response, where the landing site should be, which payload pod to use, and which UDL channels to use (when the plan included two vehicles in the air at the same time). Operators typically asked for clarification at some later point, but sometimes not until the critical time when they realized they needed it and didn't have it. This was particularly the case with setting UDL when multiple vehicle missions were planned. This omission is related to the point above with respect to checking UDL prior to launch time.

An essential consideration for the leader is who and how many people to assign to the RS team. Elements for consideration include known operator competency and operator familiarity with the terrain. Also to be considered is whether assigning a person to the RS team would leave

some other crucial position vacant. For example, during some days of the MAV ACTD 2006 Soldier experiment, the entire platoon element was not present. This limited who the PL could assign to be an operator because the platoon was short a gunner, and one of the operators was also a gunner. During the experiment, the chosen operator was always accompanied by a "supervisor," either the PSgt or the PL himself. A security team was required for them if dismounted. If a Stryker was taken to the launch site, the minimum RS team was one operator, PSgt, and a driver. The PSgt normally acted as the radio relay between the operator and the (remote) PL while the driver pulled security. When multiple missions were planned in quick succession, two operators were assigned, so that one could refuel a recently landed vehicle, while the other launched the next flight. This was insufficient personnel for quick succession night flights. In the dark, fueling became a 2-person task. The PSgt could not both help refuel and act as radio relay. The driver manned the radio instead, but he had difficulty hearing the operator. Observers actually assisted in relaying the operator's words to the driver. The point is, the PL must consider the conditions under which RS operation will occur (METT-TC again), and assign the RS team accordingly.

Defining Roles of Unit Personnel During RS Mission

Table 4 lists the observations and questions associated with the activity, "define roles of unit personnel in tracking the RS mission, interpretation of RS sensor imagery, and reporting on commander's critical information requirements (CCIR)." The goals are to make sure that the intelligence acquired by the RS gets to the people who need it in a timely manner, and to make sure that RS operation is responsive to unfolding events and the advent of new intelligence. Currently fielded RS tend to be stand alone systems, not networked with any other military digital displays. This may create some difficulties in terms of the PL keeping abreast of mission progress and fully utilizing the sensor information provided by a RS.

For now and several years to come, a human will be required to interpret sensor imagery. This includes understanding what they are seeing, and relating it to a geographic location. It is important to make sure that designated interpreters have the capability to do this. If non-natural sensors, such as IR are used, the interpreter must have the ability to understand this type of imagery. Besides understanding what they are seeing, the interpreter must also be able to judge the location. It is all too easy for imagery observers to become disoriented when the camera is pointing in one direction, but they are facing in another direction. This occurred twice during the MAV ACTD experiment. It can not be assumed that imagery interpretation or spatial orientation training will be covered in operator training. It might be necessary to designate an "interpreter" in addition to an operator, to glean relevant meaning from the sensor imagery. The interpreter may be right next to the operator or remote from the operator, depending on the ability of the system to transmit sensor data to a RVT. Multiple experiments have shown that a two person team is better at detecting targets than a single operator (Murphy, 2004; Rehfeld, Jentsch, Curtis, & Fincannon, 2005), with one person primarily responsible for control of the RS and the other for imagery interpretation.

In addition to perceptual interpretation, some degree of tactical judgment will be required to filter the information gained from the sensor imagery. For example, if the goal of a RS reconnaissance mission is to identify possible ambush sites, the interpreter needs to know about

Table 4. Defining roles of unit personnel during RS mission

Activity & Goals	Observe	Ask/AAR Questions
Activity: **Define roles of unit personnel in tracking the RS mission, interpretation of RS sensor imagery, and reporting on CCIR.** **Goals:** ▪ Intel acquired by the RS gets to the people who need it in a timely manner. ▪ RS mission can be dynamically re-planned based on new intelligence	▪ Who monitors and reports progress of the RS mission? Was responsibility for this clearly defined? ▪ Who interprets RS imagery and reports on CCIR to the PL? Was responsibility for this clearly defined? Was the communication chain clearly defined? ▪ Did the PL look at real time streaming video or imagery selected/filtered through someone else first? ▪ If person(s) were designated to monitor RS mission progress and/or imagery were they involved in mission planning? ▪ What status reports does the RS operator provide? Are there SOPs on what to report and how to report? ▪ Are RS missions changed mid-mission? Who makes the decision for this dynamic re-planning? ▪ Did the intel acquired by the RS contribute to the platoon's performance? ▪ How was intel acquired by the RS acted upon ? ▪ Were other digital systems and/or higher echelons updated with intel provided by RS?	**Ask Platoon Leader** ▪ Were you able to keep track of the progress of the RS mission? ▪ How did you utilize the intelligence provided by the RS mission? If you did not, why not? ▪ Did RS functioning meet the expectations you had during planning? Why or why not? ▪ If there was a point you lost track of the RS mission status, when and why do you think that occurred? How might you avoid this in the future? **Ask Platoon Leader, RS operator(s), and designated Third Parties** ▪ Was it clear what the RS operator was responsible for reporting or recording? ▪ Was it clear who was responsible for interpretation of sensor imagery? **Ask person(s) who performed sensor imagery interpretation** ▪ Did you experience any time pressure while interpreting sensor imagery? ▪ Did you experience any conflict between sensory analysis and your other responsibilities? ▪ Were there times when you were unsure what you were seeing? ▪ Were there times when you were unsure how to relate the imagery to a place on a map or in the environment?

terrain characteristics that make good ambush sites. This kind of tactical knowledge may be variable across operators—thus the potential need for an additional person to do interpretation. The operator or interpreter can not and should not provide a running commentary on every single thing observed. The interpreter of the imagery must be briefed on key information to report, the commander's critical information requirements (CCIR). They need to be briefed on what to look for (e.g., the latest trend in hidden explosive devices). In addition, they need to have a clear understanding of mission intent, so that they can make judgments based on what they observe (continue to watch this truck or move RS to another location). Finally, if the RS has the ability to record imagery, the operator needs to have a clear understanding about what to record and save (because of limited storage capacity).

In addition to understanding what they are seeing, the interpreter has to be able to communicate it clearly. Without some protocols for communication, there may be opportunity for confusion. During the MAV ACTD urban reconnaissance missions, each platoon member had a map with each village building clearly numbered. The PL instructed them how to refer to sides of buildings. This greatly facilitated communication between the g-MAV operators and the PL or PSgt about the location of observed targets. Without such conventions there is danger that relative terms such as left and right will be used and mislead personnel oriented in different directions. It is important that people in different locations have a clear way to communicate specific places.

In order to track MAV mission progress, PL introduced brevity codes. The operators were to radio in these codes at different stages. These specified fifteen points of a MAV mission including engine start, ready to launch, vehicle landed, vehicle retrieved, etc. This was abandoned after two missions. No one could remember the codes (letters from the phonetic alphabet: alpha, bravo, etc.), and they covered g-MAV mission progress in far more detail than the PL had time to be concerned with, or the operators cared to report. The original idea of using codes was a good one, however. The unit only needed to work out the essential elements to report; unfortunately they never really established a system. The operators were left uncertain regarding what they were supposed to report, or what actions required explicit authorization. For example, if the PL radioed to launch as quickly as possible, did they need to report when they were ready to launch and get an explicit ok? Observation indicated that the operators didn't know.

In terms of who looked at and interpreted sensory imagery during the MAV ACTD missions, several approaches were tried. Sometimes the PL stayed right by the operator and watched the OCU screen over his shoulder. PL watched the raw sensor imagery, and when so doing often directed the operator how to control the MAV and camera zoom. He might as well have been flying it himself. This clearly would not be possible if he had other things going on requiring his attention. In one instance the PL's stationary Stryker was actually overrun from behind because of lack of immediate situation awareness. The PL was busy watching over the operator's shoulder. The driver and gunner were attending to four potential enemy dismounts located to their front. Radio messages from another Stryker alerting PL about the enemy approaching from their rear were not received because of congestion on the radio nets.

Sometimes the PL would have a RVT set up, so that he could watch the sensor imagery without having to be right next to the operator. He felt that this better allowed him to multi-task, and not get caught up in micro-managing MAV operation. More frequently, communications concerning real-time imagery were radio-relayed to the PL (operator to PSgt to PL, although sometimes there was an additional person between the PSgt and the PL). When such a chain is used, it is important that participants understand what to communicate and how to communicate.

The final element of this activity is acting on the intelligence information gathered from the RS. There is no point in employing a RSTA system if the information it provides is not used. In order to make the most use of it, the PL may need to think through contingency plans ahead of time, so that he can quickly and efficiently re-task his squads based on unfolding events. He must also consider what information needs to be sent to his higher command, either through radio contact or the updating of his digital military systems. In some cases, PL may need to designate a person responsible for this activity. This will continue to be an issue until RS are networked with digital command and control systems and some kind of automated target recognition is available.

Troop Leading Procedures and Pre-Employment Checks

Table 5 lists the observations and questions associated with the activity, "Pre-launch checks." The associated goal is to make sure that all preparations for employment of the RS are conducted in a timely manner, so that the RS mission can be executed on schedule. Part of this involves clear delegation regarding who has the responsibility to conduct the associated tasks involved in preparing for RS employment. Fundamental to RS employment is making sure that a dedicated communications frequency is available for data passing between the GCS and RS platform (UDL). Additionally, for air vehicles, air space authorization may be required, and procedures for obtaining this must be established. All practical considerations regarding the particular RS system should be checked. Is the platform in working order? Are batteries charged? Is fuel available? For small RSs, some assembly of modular parts is likely. Are all the parts present? Will any spare parts be taken on the mission? Is a technical manual being brought along?

During the MAV ACTD training session, operators were instructed to always use a checklist while emplacing the MAV and conducting pre-launch checks. A checklist was provided in the back of the technical manual. Operators, however, did not routinely use a checklist, and were overconfident in their ability to perform the required tasks without one. Technical manuals tended to be pulled out only when a problem was encountered, or an NCO insisted that operators had one. Checklists might have been used more if they were in a different format (e.g., a separate checklist card, instead of a page in the back of the technical manual). Moreover, there was some confusion about whether technical manuals were supposed to stay with operators or systems. Initially operators packed the manual with the system; but the next day, they might receive a different system to use from Honeywell, without a manual inside the case. Working out procedures like this may seem trivial but can payoff greatly down the line in terms of timely mission starts.

Table 5. Troop leading procedures and pre-employment checks

Activity & Goals	Observe	Ask/AAR Questions
Activity: **Pre-employment checks:** **Goals:** ▪ Necessary RS-related equipment and supplies are present and in fully working order ▪ Download and upload frequencies have been cleared for use ▪ Coordination with higher on A2C2 (air vehicles)	▪ Is a checklist being used to make sure no items/steps are overlooked? ▪ Have uplink/downlink frequencies been coordinated internally and with adjacent units? ▪ Were any crucial items missing or steps skipped before attempt to launch?	**<u>Ask Platoon Leader and RS Operators</u>** ▪ Who is responsible for selecting OCU/ RS communication channels? ▪ Who is responsible for deconflicting channels/frequencies within the unit if multiple platforms will be used? What about deconflicting with adjacent units? ▪ Who is responsible for ensuring that pre-employment checks are done according to SOP? **<u>Ask RS Operators</u>** ▪ Is it clear when all your pre-employment checks should be performed? ▪ Were there any technical problems encountered during pre-employment checks? How did you deal with them? ▪ Are aware of unit SOPs for pre-employment checks? Did you follow them?

Errors during pre-launch checks and procedures led to delays in several RS missions because certain items or tasks were omitted. In one instance the tuning rod required for tuning the MAV engine was missing. In another instance, the person setting up the platform (who was not the subsequent operator) forgot to connect the fuel line; it took quite a while to figure out that this was the reason the engine would not start. In another instance, the MAV was set up with the wrong payload pod. The operator decided to switch out pods, but did not consult the manual and did not follow the correct procedures. This ultimately ended in an aborted mission. Finally, it has already been mentioned that deconflicting and checking the UDL was often left to the launch time, instead of being checked ahead of time.

Partial support for pre-flight checks was provided by the OCU. The operator had to go through a series of steps listed on the OCU before the g-MAV engine could be started. In general, compliance with pre-employment checks could be encouraged by better job aide design (e.g., checklists that can be tucked away in a pocket), or are required by system startup software. In addition, requirements to file checklists after each mission might also aid compliance.

Develop or Refine Unit SOPs and TTP

Table 6 lists the observations and questions associated with the activity, “Develop or refine unit SOPs and TTP,” with the overall goal of improving efficiency and effectiveness of RS employment. Examples of various activities that could be addressed by an SOP or TTP are also listed. The observations suggested in this row of the PACERS table are to a large extent redundant with items found in other rows; however, associated questions are aimed at encouraging the unit to identify ways to improve their procedures. Mistakes and inefficiencies may be identified during AAR, but it takes additional initiative to decide how to put procedures in place in order to avoid these same mistakes in the future. It is one thing to identify lessons from past mistakes, another to actually take corrective action.

Several of the SOP a unit may find useful will likely deal with the specific quirks of the system they are using, and which will only be discovered with increasing experience under varying conditions. SOP may include work-arounds for discovered equipment inadequacies in particular situations. For example, in the MAV ACTD 2006 Soldier Experiment, a flaw in the housing of the near-ground altitude detector allowed water to collect inside the housing during rain. This detector is used to determine automatic shut off of the MAV engine during landing. The consequence was if a land command was given, the sensor could be “fooled” into thinking it was close to the ground because of the water in the housing, and shut off the engine when in fact the g-MAV was still high in the air (resulting in a crash). Once this was discovered, the unit adopted the policy of manually lowering altitude to a few feet off the ground before issuing a land command, if there was any chance that water may have collected below the sensor.

An example of a more tactical procedure that might require development has to do with coordination of fires, to avoid destruction of the RS platform. During some of the ACTD experiment missions, PL and squad leaders had the option to call for indirect fires. The PL was asked what he would do to ensure that a MAV in the air would not be hit by incoming mortars. He had discussed this with his commander, and the strategy suggested was to raise MAV altitude above that of mortar trajectory, when a call for indirect fire was made. In order to implement this it would be important that the RS operator is made aware that a call for fire had been given. Therefore, an SOP on the communications chain to ensure operator notification would be useful.

Operation at a Site Remote from the Rest of the Unit

Table 7 lists the observations and questions associated with situations in which the RS team is operating from a site remote from the rest of the unit. This section is somewhat redundant with the section on pre-launch checks; however, it also addresses the situation in which the RS team is responsible for its own security. The observations and questions are aimed at ensuring that the RS team understands how to select an appropriate site from which to operate. The appropriateness of a site should be considered from both a security aspect and RS aspect. For the latter, there may be specific terrain features that could hinder UDL, GPS signals, or maneuver of the RS vehicle.

Table 6. Develop or Refine Unit SOP and TTP

Activity & Goals	Observe	Ask/AAR Questions
Activity: **Develop or refine unit SOPs and TTP** **Goals:** Improve efficiency and effectiveness of RS employment Examples: -- mission specification format (RS-OPORDER) --response to specific threat situations to an airborne RS --response to specific threat situations to a remote RS team -- response to loss of link -- response to other technical difficulties with RS -- significant events during the RS mission that the operator should report -- language for verbal communication regarding significant RS events -- language for verbal communication regarding target location --A2C2 coordination -- frequency coordination with nearby units --Use of checklists --Refinement of SOPs based on lessons learned -- Development of new TTP based on lessons learned	▪ Was the RS mission briefed systematically in a step by step fashion or were specifics written in a standard format? ▪ Did people involved in controlling the RS appear confident and certain about what they were supposed to be doing? ▪ Were there any technical or other difficulties which could have been avoided? ▪ If the unit has SOPs, are they being followed? ▪ Was there any loss of uplink/downlink with the RS? How was this reacted to? ▪ Were there any real or potential mishaps? What were the likely causes?	**<u>Ask Platoon Leader and RS Operators</u>** ▪ Is there anything that happened during the mission that suggests the basis for a new SOP or TTP? ▪ Is there a unit SOP that defines the information that should be included in a RS mission plan? ▪ Do you have any SOPs associated with any key situations (e.g., detection of an enemy sniper)? ▪ Were there instances in which you found verbal communications regarding the RS confusing? How could these be addressed through an SOP? ▪ Did new information requirements become evident during a mission? If yes, what was done to address the need?

Table 7. Operation at a Site Remote from the Rest of the Unit

Activity & Goals	Observe	Ask/AAR Questions
Activitiy: **Preparation for launch/recovery at a remote site** **Goals:** ▪ RS team safety ▪ Timely RS launch	▪ Does the team maintain security en-route and immediately set up security upon arrival? ▪ Is the site checked for suitability? ▪ Are checklists used during the set up or break down processes? ▪ Is everyone in the RS team fully employed either providing security or preparing for launch? ▪ Is RS launched on schedule? ▪ If multiple missions are conducted from the same location, what is the inter-mission turn around time? Was it as planned?	**<u>Ask RS team</u>** ▪ Did you have adequate personnel to secure the launch site? ▪ Were problems encountered in establishing communications, GPS signal, fueling procedures, etc.?

During the MAV ACTD Soldier Experiment, there was often inadequate 360 degree security at a remote operations site, primarily due to lack of personnel. Had this been a real mission, as opposed to an experiment, the PL would have had to seriously question whether a remote operating team was feasible.

Record Keeping

Table 8 lists the observations and questions associated with record keeping activities. It is important that the unit knows how to handle safety incidents, as well as record operator hours and systems logs for maintenance purposes. In some cases the records to be kept may be dictated by higher authorities. It is important that responsibilities are assigned for these tasks, and that assigned personnel understand the requirements. Of course, these duties might not be necessary if an RS is being tested by a unit in a one-off experiment. In the case of the MAV ACTD experiment, it was anticipated that the 25^{th} ID would subsequently continue to evaluate the g-MAV, supported by the Army. Therefore, there was some recording of personnel training and flight experiences, as they would likely be involved in future exercises. What exactly needed to be recorded, and the format of the records was not clearly specified (the MAV being an experimental system); however, the unit was consulting with the Army's UAV Center of Excellence for guidance on record keeping.

Table 8. Record Keeping

Activity & Goals	Observe	Ask/AAR Questions
Activity: **Record keeping** **Goals:** ▪ Safety incidents recorded and reported ▪ Use and Maintenance logs kept up to date ▪ Operator training currency and flight logbooks kept up to date	▪ Are records being made and kept in an organized way? ▪ Is system operation in compliance with safety release specifications?	**Ask Unit** ▪ Do they know what defines a safety incident? ▪ Do they know the operating parameters specified in the safety release? ▪ Does each system have a maintenance log? ▪ Does each operator keep a logbook?

CONCLUSIONS AND RECOMMENDATIONS

PACERS considers the application of RS at platoon level -- a situation where the work involved in planning and executing employment strategy and analyzing sensor feeds will be performed without a dedicated staff. Although PACERS is based largely on the author's research and observations concerning small aerial RS, it is intended to be applicable to any small RS, aerial or ground-based, or even littoral, where the RS is employed by a designated ad hoc team from within the unit (as opposed to a dedicated attached team). The extent to which PACERS is useful, independent of the RS system, will need to be assessed by trial application to units equipped with RS systems other than the MAV.

In an attempt to remain generic, PACERS deliberately avoided addressing individual operator training. The advantage of a generic approach is that it avoids the necessity for trainers to become conversant with the details of a myriad of systems, as well as the need for continuous revision due to technical upgrades. Nevertheless, there are aspects of operator training that are relevant to system employment, which will be mentioned here. Depending on who designs the training operators receive, and how much time is allotted for operator training, operators may not actually receive all the training truly required to operate the system. For example, a table of approved UDL frequencies for the local area might be required, but the operator may have not been trained where to get this or how to load it into the OCU even if he/she had it. Or map imagery might be required for the operating area but the operator may have not have been trained how to integrate available imagery into the OCU. Or, the OCU may be capable of recording video or still photos, but the operator may not have been trained how to download these for export to other systems.

Even if operator training has covered these many technical aspects, there are potentially several other skills required for employment which have not been trained. For example, an RS might be equipped with an IR camera; however, training on IR imagery interpretation may not be a part of operator training. Or, terrain analysis skills might be required to set routes, interpret maps, or interpret sensor images; but operator training may not address terrain analysis skills. The point is that to employ a RS beneficially, there are other skills required besides mere

operator training. Leaders will have to include knowledge of how these other skills are distributed among their personnel when assigning RS teams.

Another variable element in operator training is trouble shooting. Training will likely vary in how much attention is given to problem solving when something goes wrong. But things do inevitably go wrong (Meshesha, et al., 2007; Murphy, Stover, & Burke, 2005). Explicit practice on dealing with malfunctions or other problems is recommended, and leaders may need to arrange opportunities for this if it was not adequately dealt with during operator training. Knowledge of how different members of the unit deal with various dilemmas (both practically and emotionally) may need to be considered in assigning RS teams. Recall the example of the disconnected fuel line given above. The main reason that happened was that Soldiers had encountered so many technical problems during the experiment, that it was hard for them to imagine that this time, the problem was as simple as an unconnected fuel line. Of course, if a checklist had been used, the problem would have been avoided.

Providing units with guidance on how to apply new technology when that technology is constantly changing is a real challenge. ARI's FBCB2 Exploitation Tool and the Digital TOC Integration Guide will require repeated updating to reflect changes in the capabilities of networked systems. This report has tried to avoid this problem by providing guidance that is more related to functional aspects of RSTA RS, as opposed to the specifics of any one particular system. The assumption is that the underlying goals of employing a RSTA RS system will remain the same, even though the specifics of the system might change. Yet changes in technological capabilities may eventually make the guidance provided here obsolete. In particular, some of the issues addressed here may become non-issues when RS become better integrated with C3 networks and/or when RS themselves gain more intelligence and autonomy. For now, however, there remain questions of how the position of and the information provided by the RS will be integrated with the rest of the Army's digital battle command systems such as FBCB2, Command Post of the Future (CPOF), Advanced Field Artillery Tactical Data Systems (AFATDS), and Tactical Airspace Integration System (TAIS).

Finally, it is recommended that designers of RS systems give some consideration to incorporating the collection of data for AAR aids into their systems. Many small RS systems include a tablet computer, and could record data on how the RS was employed during a mission. This includes recording of platform routes, sensor coverage and sensor imagery, mission timings, and alerts and warnings sent to the operator by the system. Using the RS itself to collect and display these data in the form of visual aids could greatly facilitate the AAR process.

REFERENCES

Alberts, D. S. & Hayes, R. E. (2002). Code of best practice experimentation. *Command and Control Research Program Information Age Transformation Series*. Washington, D.C.

Durlach, P. J. (2005). Training for Multicell and Dismounted Command and Control. *Proceedings of the Interservice/Industry Training, Simulation, and Education Conference (I/ITSEC),* December, Orlando, FL.

Leibrecht, B. C., Lockaby, K. J., & Meliza, L. L. (2003). *A practical guide for exploiting FBCB2 capabilities* (ARI Research Product 2003-05)

Leibrecht, B. C., Lockaby, K. J., Perrault, A. M., Strauss, C. P., and Meliza, L. L. (2006) Tailored Exercise Planning and Feedback for Digitized Units (ARI Research Report 1858).

Meshesha, D., Dusina, J. Pandullo, M., Bruner, S., Edwards, D., Ruecking, D., Scalsky, D., Farquhar, J., Schmid, M., Buck, S., Johnson, K., Wallace, P., Chandler, R., Nellans, T., & Strukel, S. (2007). Air Assault Expeditionary Force (AAEF) Spiral C Experiment Final Report. U.S. Army Test and Evaluation Command, Alexandria, VA.

Murphy, R. (2004). Human-robot interaction in rescue robotics. *IEEE Transactions on Systems, Man, and Cybernetics-Part C: Applications and Reviews,* Vol. 34 (2), 138-153.

Murphy, R. R., Stover, S., & Burke, J. (2005). *Rescue Robot Awareness Training*. Tampa, FL: Center for Robot-Assisted Search and Rescue and University of South Florida.

Odom, T. P., Gates, J. W., Hardwich, J., & Ehrlich, R. (2005) Transformation: Victory rests with small units. *Military Review. May – June,* 81–85.

Office of the Secretary of Defense (2002). Unmanned Aerial Vehicles Roadmap, 2002- 2027. Washington, D.C.

Switzer, R. (2005). Combat success rests with platoons. Center for Army Lessons Learned. Article downloaded 10/31/2005 from https://call2.army.mil/products/training-techniques/asp/articles/COMBAT/combat.asp.

Rehfeld, S. A., Jentsch, F. G., Curtis, M., & Fincannon, T. (2005). Collaborative teamwork with unmanned ground vehicles in military missions. *Proceedings of the 11th Annual Human-Computer Interaction International Conference,* Las Vegas, NV.

U.S. Army Training and Doctrine Command Office of the Chief of Public Affairs (2006). AAEF tests the capability of air assault. Article downloaded 01/26/07 from http://www.tradoc.army.mil/pao/TNSarchives/December%202006/120606-1.html.

APPENDIX A: PACERS TABLE

Activity & Goals	Observe	Ask/AAR Questions
Activity: Decide whether/how to employ the RS **Goals:** Potential benefits vs. risks of employing the RS are considered in light of overall mission objectives, METT-TC, and weather. **SEE APPENDIX B FOR ADDITIONAL DETAILS**	▪ Was airspace clearance checked (air systems)? ▪ Was there any coordination with adjacent units wrt RS employment? Specifically on communications frequencies? ▪ If indirect fires are available, was there any consideration of how this might impact RS employment?	**<u>Ask Platoon Leader</u>** ▪ What factors did you consider in deciding to employ (or not employ) the RS? ▪ What did you view as the potential advantages of using the RS? ▪ What did you view as the potential disadvantages of using the RS? ▪ Is there a process for coordinating with adjacent units?
Activity: Select RS team* and plan RS missions within the overall mission context **Goals:** ▪ Provide adequate number of personnel to conduct RS operations and provide security ▪ Ensure RS team members understand their mission and individual responsibilities ▪ Ensure RS team has adequate time to move to emplacement site and prepare RS for maneuver ▪ Ensure RS employment is integrated into the overall mission *** RS team**—any personnel involved in - Operation of the RS - Interpretation and/or communication of information gained from the RS - Security for above	▪ Did PL or PSgt ask questions to ensure RS team understood its mission? ▪ Was a rehearsal conducted? ▪ Did the rehearsal cover the entire RS mission? ▪ Were CCIRs/PIRs explicitly discussed? ▪ Did the PL prepare a written RS-OPORDER? ▪ Was all the information required for the RS team operations briefed? (SEE APPENDIX C) ▪ If the RS team would be remote from the rest of the unit was a trigger for reuniting specified? ▪ When entering autonomous missions in the RS OCU, does the user check this mission with respect to terrain/other factors ▪ Was there a discussion on how to program response to loss of UDL links?	**<u>Ask RS Team</u>** ▪ What was your mission? ▪ How did your mission relate to the overall mission? ▪ Were you briefed on all the information you needed to conduct your mission? ▪ Were problems encountered in preparing to launch that might have been addressed with additional personnel? ▪ Did you run into any situations that you were not sure how to respond to? ▪ Was time a problem in preparing for the launch? ▪ Were each individual's responsibilities clearly defined?

Activity & Goals	Observe	Ask/AAR Questions
Activity: **Define roles of unit personnel in tracking the RS mission, interpretation of RS sensor imagery, and reporting on CCIRs.** **Goals:** ▪ Intel acquired by the RS gets to the people who need it in a timely manner. ▪ RS mission can be dynamically re-planned based on new intelligence	▪ Who monitors and reports progress of the RS mission? Was responsibility for this clearly defined? ▪ Who interprets RS imagery and reports on CCIRs to the PL? Was responsibility for this clearly defined? Was the communication chain clearly defined? ▪ Did the PL look at real time streaming video or imagery selected/filtered through someone else first? ▪ If person(s) were designated to monitor RS mission progress and/or imagery were they involved in mission planning? ▪ What status reports does the RS operator provide? Are there SOPs on what to report and how to report? ▪ Are RS missions changed mid-mission? Who makes the decision for this dynamic re-planning? ▪ Did the intel acquired by the RS contribute to the platoon's performance? ▪ How was intel acquired by the RS acted upon ? ▪ Were other digital systems and/or higher echelons updated with intel provided by RS?	**Ask Platoon Leader** ▪ Were you able to keep track of the progress of the RS mission? ▪ How did you utilize the intelligence provided by the RS mission? If you did not, why not? ▪ Did RS functioning meet the expectations you had during planning? Why or why not? ▪ If there was a point you lost track of the RS mission status, when and why do you think that occurred? How might you avoid this in the future? **Ask Platoon Leader, RS operator(s), and designated Third Parties** ▪ Was it clear what the RS operator was responsible for reporting or recording? ▪ Was it clear who was responsible for interpretation of sensor imagery? **Ask person(s) who performed sensor imagery interpretation** ▪ Did you experience any time pressure while interpreting sensor imagery? ▪ Did you experience any conflict between sensory analysis and your other responsibilities? ▪ Were there times when you were unsure what you were seeing? ▪ Were there times when you were unsure how to relate the imagery to a place on a map or in the environment?

Activity & Goals	Observe	Ask/AAR Questions
Activity: **Pre-employment checks:** **Goals:** ▪ Necessary RS-related equipment and supplies are present and in fully working order ▪ Download and upload frequencies have been cleared for use ▪ Coordination with higher on A2C2 (air vehicles)	▪ Is a checklist being used to make sure no items/steps are overlooked? ▪ Have uplink/downlink frequencies been coordinated internally and with adjacent units? ▪ Were any crucial items missing or steps skipped before attempt to launch?	**Ask Platoon Leader and RS Operators** ▪ Who is responsible for selecting OCU/ RS communication channels? ▪ Who is responsible for deconflicting channels/frequencies within the unit if multiple platforms will be used? What about deconflicting with adjacent units? ▪ Who is responsible for ensuring that pre-employment checks are done according to SOP? **Ask RS Operators** ▪ Is it clear when all your pre-employment checks should be performed? ▪ Were there any technical problems encountered during pre-employment checks? How did you deal with them? ▪ Are aware of unit SOPs for pre-employment checks? Did you follow them?

Activity & Goals	Observe	Ask/AAR Questions
Activity: **Develop or refine unit SOPs and TTPs** **Goals:** Improve efficiency and effectiveness of RS employment Examples: -- mission specification format (RS-OPORDER) --response to specific threat situations to an airborne RS --response to specific threat situations to a remote RS team -- response to loss of link -- response to other technical difficulties with RS -- significant events during the RS mission that the operator should report -- language for verbal communication regarding significant RS events -- language for verbal communication regarding target location --A2C2 coordination -- frequency coordination with nearby units --Use of checklists --Refinement of SOPs based on lessons learned -- Development of new TTP based on lessons learned	▪ Was the RS mission briefed systematically in a step by step fashion or were specifics written in a standard format? ▪ Did people involved in controlling the RS appear confident and certain about what they were supposed to be doing? ▪ Were there any technical or other difficulties which could have been avoided? ▪ If the unit has SOPs, are they being followed? ▪ Was there any loss of uplink/downlink with the RS? How was this reacted to? ▪ Were there any real or potential mishaps? What were the likely causes?	**<u>Ask Platoon Leader and RS Operators</u>** ▪ Is there anything that happened during the mission that suggests the basis for a new SOP or TTP? ▪ Is there a unit SOP that defines the information that should be included in a RS mission plan? ▪ Do you have any SOPs associated with any key situations (e.g., detection of an enemy sniper)? ▪ Were there instances in which you found verbal communications regarding the RS confusing? How could these be addressed through an SOP? ▪ Did new information requirements become evident during a mission? If yes, what was done to address the need?

Activity & Goals	Observe	Ask/AAR Questions
Activitiy: **Preparation for launch/recovery at a remote site** **Goals:** ▪ RS team safety ▪ Timely RS launch	▪ Does the team maintain security en-route and immediately set up security upon arrival? ▪ Is the site checked for suitability? ▪ Are checklists used during the set up or break down processes? ▪ Is everyone in the RS team fully employed either providing security or preparing for launch? ▪ Is RS launched on schedule? ▪ If multiple missions are conducted from the same location, what is the inter-mission turn around time? Was it as planned?	**<u>Ask RS team</u>** ▪ Did you have adequate personnel to secure the launch site? ▪ Were problems encountered in establishing communications, GPS signal, fueling procedures, etc.?
Activity: **Record keeping** **Goals:** ▪ Safety incidents recorded and reported ▪ Use and Maintenance logs kept up to date ▪ Operator training currency and flight logbooks kept up to date	▪ Are records being made and kept in an organized way? ▪ Is system operation in compliance with safety release specifications?	**<u>Ask Unit</u>** ▪ Do they know what defines a safety incident? ▪ Do they know the operating parameters specified in the safety release? ▪ Does each system have a maintenance log? ▪ Does each operator keep a logbook?
CCIR Commander's Critical Information Requirement METT-TC Mission, Enemy, Troops, Terrain/Weather, Time, Civilians OCU Operator Control Unit PIR Priority Information Requirement PL Platoon Leader PSgt Platoon Sergeant SOP Standard Operating Procedure TTP Tactics, Techniques, and Procedures RS Robotic System WRT with respect to		

APPENDIX B: MISSION, ENEMY, TIME, TROOPS, TERRAIN, AND CIVILIAN CONSIDERATIONS IN ROBOTIC SYSTEM EMPLOYMENT

Mission
- What are the critical information requirements (CCIRS) for this mission?
- Considering all assets available, how could information collected by the RS best support the mission?
- Can the RS system provide information that nothing else can?
- Can the RS system provide information that could be obtained some other way, but with less risk?
- How would employment of the RS complicate mission synchronization?
- Could the RS system be used as a communications relay?
- What are the trade-offs in risks vs. benefits in RS employment?

Enemy
- Could employment of the RS give away mission intentions or friendly positions?
- Could the RS be used for deception?
- What are the ways the enemy could detect the RS?
- What are the ways the enemy could disable the RS?

Time
- What are the time requirements to prepare for employment of the RS?
- What are the time constraints on duration of RS employment?
- Do these requirements and constraints fit with the needs of the mission?

Troops
- Are there sufficient personnel for RS employment?
- Do the personnel available possess the correct training and skills?
- Will a security element be required for the RS team?
- Is the equipment in full operational condition?
- Are the necessary supporting equipment and supplies all available?
- Is a dedicated UDL channel available? Has it been coordinated with adjacent units?
- Is air space clearance required?

Terrain
- Does the weather allow employment?
- Are there aspects of the terrain that will interfere with line of sight communications?
- For SUGVS: is the ground traversable?
- Are there appropriate emplacement or launch sites?
- Are there appropriate recovery sites?
- If capable of programming, how should the RS behave subsequent to a loss of communications with the operator?

Civilians
- How might civilians respond to the RS?
- How might RS employment pose risk to civilians?

APPENDIX C: INFORMATION TO BE INCLUDED IN RS-OPORDER

This information should be included as an annex to the PL's OPORD. As such it does not specify information that should already be in the OPORD, such as overall mission objective, concept of operations, CCIRS, tasks to squads, etc.

- Main RS mission objectives
- RS team personnel and responsibilities
- Launch or Emplacement Location (and route to it, if remote)
- Recovery Location
- Payload
- UDL channel
- Means of operator control (manual or semi-autonomous)
- Intended route of travel for RS systems
- Who has the authority for dynamic replanning of RS mission
- Time or trigger for RS mission start
- Other coordinating instructions
- Actions on loss of UDL
- Actions on contact (RS team)
- Actions on contact (RS platform)
- RS mission abort criteria
- Communications channels and networks (equipment and people)
- RS mission status information to report (what to report, brevity codes, and means of communication)
- RS sensor data to report (what to report, when to report, brevity codes, and means of communication)
- RS sensor data to record (what to record or how, if multiple methods)

APPENDIX D: ACRONYMS

A2C2	Army Airspace Command and Control
AAEF	Air Assault Expeditionary Force
AAR	After Action Review
ABCS	Army Battle Command System
ACTD	Advanced Concept Technology Demonstration
AFATDS	Advanced Field Artillery Tactical Data Systems
ARI	U.S. Army Research Institute for the Behavioral and Social Sciences
ARV	Armed Robotic Vehicle
ATO	Army Technology Objective
BCT	Brigade Combat Team
C3	Command, Control, and Communication (systems)
CCIR	Commander’s Critical Information Requirements
CPOF	Command Post of the Future
EO	Electro-optical (camera)
FBCB2	Force XXI Battle Command, Brigade and Below (system)
FCS	Future Combat System
GCS	Ground Control Station
GDT	Ground Data Terminal
GPS	Global Positioning System
IR	Infrared (camera)
LOS	Line of Sight
LRAS3	Long-Range Advance Scout Surveillance System
MAV	Micro Air Vehicle
METT-TC	Mission, Enemy, Time, Troops, Terrain, and Civilians
MULE	Multifunctional Utility/Logistics and Equipment
NCO	Non-Commissioned Officer
OCU	Operator Control Unit
OP-ORDER	Operations Order
PACERS	Platoon Aid for Collective Employment of Robotic Systems
PIR	Priority Information Requirement
PL	Platoon Leader
PSgt	Platoon Sergeant
RS	Robotic System
RSTA	Reconnaissance, surveillance, and target acquisition
RVT	Remote Video Terminal
SOP	Standard Operating Procedure
SUAS	Small Unmanned Aerial System
SUGV	Small Unmanned Ground Vehicle
TAIS	Tactical Airspace Integration System

TOC	Tactical Operations Center
TTP	Training, Tactics, and Procedures
UAS	Unmanned Aerial System
UDL	Up and Down Links between GCS and RS
UGV	Unmanned Ground Vehicle
WRT	With Respect To